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DFO Atlantic Fisheries
Research Document 96/132

MPO Pêches de l'Atlantique
Document de recherche 96/132

Scallop stock status for 1995 - Eastern Scotian Shelf and German Bank

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104-07156/

ABSTRACT

Scallop fishing grounds on the eastern Scotian Shelf (Middle Grounds, Sable Island Bank, and Western Bank) were grouped under one allocation plan in 1995 with a TAC of 150 t. The catch limit was based on the low end of historical catches over the period 1980 to 1994. The management plan is focusing on a stock recovery strategy. Catches have yet to return to the long term average of 250 t. Effort has followed the same trends as catches. Both have increased slightly from 1994 to 1995. CPUE's have improved by 15%.

There has been an improvement in the abundance index from research surveys mainly due to young recruits. However, they would contribute little yield to the fishery at 60 - 90+ meats per 500 g. The meat count regulation at 45 meats per 500 g will allow the incoming recruitment to realise its growth potential. All indications are that recent catch levels appear appropriate.

On the western Scotian Shelf, the German Bank scallop fishery resumed in 1993 after a 7-year interruption. In 1995, the fishery closed after 400 t were caught. Effort has been steadily rising since 1993. Catch-rates decreased 50% from 1994 to 1995. Survey results showed good densities of ages 7+ scallops.

The rapid decline in the 1995 fishery performance would suggest that recent catch levels are not sustainable and that a TAC of 100 t would be more appropriate. Catch-rates and meat counts should be monitored.

RÉSUMÉ

Les bancs de pétoncles dans la partie est du plateau néo-écossais (Banc du Milieu, Banc de l'Ile-de-Sable, et Banc Western) furent groupés sous un seul plan d'allocation en 1995 avec un TAC de 150 t. On a basé le quota sur le segment le moins élevé des prises historiques durant la période 1980 à 1994. Le plan de gestion est orienté sur une stratégie de rétablissement du stock. Les prises n'ont pas encore atteint la moyenne à long terme de 250 t. L'effort a suivi le même profile que les prises. Tous deux ont augmenté légèrement de 1994 à 1995. Les taux de capture se sont améliorés de 15 %.

L'indice d'abondance de l'inventaire de recherche s'est amélioré grâce surtout aux jeunes recrues. Cependant, leur compte à 60 - 90+ viandes pour 500 g contribuerait peu à la pêche. Le compte de viande, 45 viandes par 500 g, permettra au nouveau recrutment de réaliser son potentiel de croissance. Tout semble indiquer que les récents niveaux de prises sont appropriés.

Dans la partie ouest du plateau néo-écossais, la pêche aux pétoncles sur le banc German a repris en 1993, après une interruption de 7 ans. En 1995, on a pêché 400 t de pétoncles. L'effort a augmenté constamment depuis 1993. Les taux de capture ont baissé de 50% de 1994 à 1995. L'inventaire de recherche a établi de bonnes densités pour les pétoncles ages 7+.

Le déclin rapide révélé par les résultats de la pêche en 1995 porte à croire que les taux de prises récents ne sont pas viables et qu'un TAC de 100 t serait plus approprié. On devrait surveiller les taux de capture et les comptes de viande.

INTRODUCTION

Up to 1994 the exploitation of offshore scallop fishing grounds on the eastern Scotian Shelf (Banquereau Bank, Middle Grounds, Western and Sable Island Banks Fig.1) was competitive. During the 15 years existence of this fishery, best catches have been around 500 t with catch-rates in the low range compared to other offshore scallop fishing grounds. Decreasing catch-rates from both the fleet and research surveys prompted the imposition of a catch limit on the fleet to initiate a possible stock recovery. A meat count (size limit) of 45 meats per 500 g is in place; lowering the count could bring a small yield improvement.

Scallop fishing grounds on the eastern Scotian Shelf have been grouped under one allocation management plan. The catch limit was based on the low-end of annual historical catches over the period 1980 to 1994. The TAC was set at 150 t in 1994 and 1995. Total catches for 1994 were 116 t, with catch-rates 40% better than in 1993. In 1995, the TAC was all caught; catch-rates rose 15% from 1994. According to the survey estimates, recruited biomass improved by a factor of 2 from 1994 to 1995.

On the western Scotian Shelf, the German Bank fishery resumed in 1993 after a 7-year interruption. It is seasonal to avoid gear conflict (lobster traps). The meat count for German Bank was lowered to 40 meats per 500 g in 1994. No biological information existed to derive a TAC. In 1993 a 200 t TAC was harvested over 7 weeks. Subsequently, a 'roll-over' TAC was agreed upon by industry and fishery managers. Increments of 200 t quota over a 6-week period were repeated provided that catch-rates were not dropping significantly and the meat count was met without difficulties. From June to mid-October 1994, 600 t were caught with good CPUE's. In 1995, 400 t were fished; performance declined rapidly during the second quota increment so the fishery stopped once the second increment had been caught.

METHODS

Fishery Information

There are two sources of information to estimate the respective fishery contributions of scallop fishing grounds on the Scotian Shelf. Offshore scallop landings are now monitored at dockside by an independent agency; sales slips used to be issued by fish buyers. Amounts landed and (NAFO / Scallop Fishing Area) areas fished are then compiled by the Statistics Division, Department of Fisheries and Oceans, Halifax. The other source of information about the origin of the catch is from logbooks. Logged catches are used to estimate catch removals on a scallop bed basis. There are at times discrepancies between statistical and logged catches as NAFO sub-subareas do not correspond to the physical location of particular scallop beds and may cut a major scallop bed in two. This inadequacy of the statistics system was previously described in Robert et al. (MS 1984).

All vessels (over 25.5 G.T. or 14 m L.O.A.) fishing the Scotian Shelf are required

to keep logbooks to record daily fishing activities. Daily log records supply information on the catch and its location and fishing effort such as hours spent fishing, width of gear, and number of crew. Catch-rate estimates may be computed when complete effort data (location, hours fished, gear, etc.) are provided with respect to the catch (Class 1 data). Total effort may be estimated according to the effort that generated the Class 1 catch. The productivity in terms of removals of a specific scallop bed may also be established assuming that the catch with known location is representative of the total catch from that bed.

Scallop Fleets

Two components of the Canadian offshore fleet may drag for scallops on the Scotian Shelf. The deep-sea fleet, L.O.A. over 19.8 m, is excluded from a 12 nautical miles zone near-shore, and waters in the Bay of Fundy and approaches north of latitude 43° 40' N following the Inshore/Offshore Agreement (fall 1986). The Bay of Fundy fleet, mostly L.O.A. between 14 and 19.8 m (Bay of Fundy licensed vessels), has to restrict its activities on the Scotian Shelf to the upper parts of the Lurcher Shoals above latitude 43° 40' N following the Agreement. The status of scallop beds above latitude 43° 40' N is not addressed in this document.

The deep-sea fleet uses a New Bedford offshore scallop drag varying in width from 3.96 to 4.88 m. Two drags are fished simultaneously, one on each side of the vessel.

Catch Sampling

Sampling of the catch has been sporadic for most years and does not meet target levels to sample the catch adequately. Port coverage varied greatly, from none for southwest Nova Scotia ports like Liverpool and Saulnierville to somewhat fair in the Lunenburg - Riverport area. Not all ports are necessarily involved in any particular Scotian Shelf fishery. Starting in July, 1995 all landings were sampled under an industry sponsored program. Although the purpose of this program was not to collect catch data specifically for size distribution, it enhanced the catch database nevertheless.

Survey Procedures on the Scotian Shelf

The catch distribution derived from log records for each particular fishing ground is used to stratify survey stations which are randomised within arbitrarily set strata. At times, an exploratory stratum may be added. Catches from the deep-sea fleet over the year prior to the survey are considered. Annual surveys are carried out in May. A new survey series began in 1994 with the retirement of the Government survey vessel. A commercial scallop dragger is now carrying out research survey work. With the implementation of catch limit on the eastern Scotian Shelf in 1994, it was felt necessary to have a good baseline of stock estimate from the survey data. Stratification for the 1994 survey from the 1993 catch would not have provided a good coverage since the grounds exploited were very limited. More tows were added to the survey (exploratory stratum) to cover grounds fished in the past on Sable Island/Western Bank area and Middle Grounds. Limited fishing activities in 1994 could not provide a survey catch stratification (for 1995) covering the majority of exploited grounds. The 1994 survey stations were repeated to give good coverage. The

relative changes in abundance estimates from 1994 to 1995 could also give some indications of the recovery of the grounds under the present management plan. The 1995 survey catch stratification for German Bank was based on the 1994 fishing activities.

The survey gear was a 2.44 m wide New Bedford offshore dredge (75 mm ring size) lined with 38 mm stretch mesh polypropylene netting (unlined for German Bank). Tows were of ten minutes duration; distance towed was determined from the continuous recording of coordinates provided by a GPS (Global Positioning System) differential receiver via a microcomputer or, exceptionally, from positions taken at the start and the end of the tow. Catches were later standardised to a tow length of 800 m. For each tow, the following data were recorded: 1) shell heights in 5 mm intervals for all live scallops and cluckers (shells with both valves still attached at the hinge); 2) tow location (position as latitude and longitude); 3) depth (m); 4) compass bearing for direction of tow; 5) duration of tow (minutes); 6) substrate type; 7) fullness of the drag (count of the number of vertical rings covered by the catch); and 8) total scallop catch as a round weight (kg).

Standardized survey catch-rates were contoured to represent the spatial distribution of the scallop aggregations following a procedure described in Black (MS 1988). Data points describe a three dimensional surface with latitude, longitude, and number of scallops per tow to be plotted. A surface is formed by defining Delaunay triangles from an algorithm found in Watson (1982); the data points become the vertices of triangles connecting nearest neighbour points. The surface between adjacent contour levels, in this case the relative abundance of scallops, is represented as darkening shades of grey. Contours may be smoothed by interpolating the surface using the inverse weighting of gradients (slopes of triangles). The sides of the Delaunay triangles are divided into equal segments (chords) to establish the interpolation points. For example, dividing the sides into 4 segments gives 16 subtriangles. The interpolation points become new vertices. This method assumes that the data points near the point in question contribute more than distant points (see also Watson and Philip 1985). Each triangle is assumed to have a flat surface. The summation of the volumes of all triangles under the contoured surface is equal to the total volume, a potential abundance estimate for the survey area. The degree of interpolation will affect the volume estimates. Experimental work indicates that volume estimates stabilise with a minimum of variation (5%) (Robert et al. MS 1989) after 16 or more subtriangles.

Fishery Performance on a Scallop Bed Basis

Catch and effort data were plotted from locations provided in logbooks to investigate the concentrations of fishing activity presumably related to abundance, hence location of scallop beds exploited commercially. Log returns for the Scotian Shelf fishery are excellent with over 90% class 1 data. Isolines of fishery data were drawn and surfaces contoured similar to the plotting of survey catch-rates, thus mapping the distribution and fishery characteristics of scallop beds.

Relevant Biological Information

Biological information dealing only with growth rate and allometry of meat weight on shell height are given here. Biological data has been gathered since 1982 as part of an on-going study of somatic and gonadal growth cycles.

Areas such as Sable Island / Western Bank have good sampling coverage from the commercial fleet as exploitation spreads over the last 15 years.

Samples from 1982 to 1989 surveys and samples collected from the fleet up to 1989 were used in the analyses. Table 1 presents variables of von Bertalanffy growth curves and the number of scallop shells which rings have been read for each area. It also gives the regression parameters for estimating meat yield as a function of shell height and the number of animals examined. In an attempt to reduce seasonal effects in yield conditions, samples collected at all times of the year have been included in the analysis to approximate a 'year round' value. Some biological information was tentatively derived with a small sample from Banquereau Bank collected during earlier stock surveys until more material is assembled. The Sable Island area presents a wide range of depths (20 - 100+ m) where scallop concentrations occur, leading to a great deal of heterogeneity in growth patterns. However, all data were pooled together to generate one equation for the area.

RESULTS

Scallop Fleets

Following the 1986 Inshore/Offshore Agreement, the Bay of Fundy fleet was restricted to the Lurcher Shoals on the Scotian Shelf. The deep-sea fleet continued to exploit scallop grounds in other areas of the Shelf. Vessels fished German Bank for the first time in 1993, after a lapse of 7 years. During 1995, all vessels of the offshore scallop fleet fished on the Scotian Shelf.

This document reports on the fishery performance and stock status of the eastern Scotian Shelf and German Bank on the western Scotian Shelf. The eastern Scotian Shelf includes Banquereau Bank, Middle Grounds, Western Bank, and the Sable Island area.

Banquereau Bank

Historically, Banquereau Bank (NAFO subarea 4V) has never been reported as a scallop-producing area. Catches average less than 10 t per year (Table 2). Highest landings (16 t) were reported in 1986. Banquereau Bank is exploited when poor catch-rates are encountered on the eastern Scotian Shelf. In 1993, nearly 7 t (Table 2) were caught from the west tip of Banquereau; catch-rates were low. No fishing activity has been reported since.

The 1989 survey carried out six exploratory tows on Banquereau Bank. Abundance was extremely low based on only the oldest age class (Robert et al. MS 1990). The area has not been given survey coverage since.

Middle Grounds

Middle Grounds (Fig. 1) is a shallow bank of which 900 km^2 may carry

commercial densities of scallops. Scallop production based on catches has been irregular over the last ten years (Table 3). From practically no landings reported in 1988, catches have been relatively low but rising gradually from 20 to 50 t to drop to 13 t in 1994 (Fig. 2). Catches increased slightly in 1995. Catch-rates have varied little during that period.

Sampling of the catch (Table 4) indicates that a wide range of meats are shucked with an average meat weight comparable to the ones obtained from Georges Bank. Since 1989 there has been an important weight drop (33%) in the average meat, from 21.4 to 14.4 g which later stabilised around 15 g. Low catch volumes prevented sampling in 1991, 1992, and 1994. This represents age 7 scallops at 33 meats per 500 g.

Stock surveys had shown low abundance of scallops except for the first survey in 1983. The prerecruit index rose significantly in 1988 but overall mean numbers at age are very low. Given the relatively low fishery performance no survey work was carried out between 1989-91 and 1993. Survey tows were carried out on Middle Grounds (Table 5) in 1994 to establish a baseline data. Higher densities were found in 1995 than in 1994, especially recruits (age 5+) (Tables 6 and 7). Very few prerecruits have been observed; none had been found in 1994.

Sable Island / Western Bank

The eastern Scotian Shelf has been exploited on a continuous basis for 15 years. Annual landings have never exceeded 700 t. Western Bank and the Sable Island area have the main scallop beds exploited by that fishery. In years of poor performance, exploitation extends to the immediate vicinity of Sable Island, and Banquereau Bank and Middle Grounds (NAFO sub sub-areas 4Wf, g, h, j, l, and u designated here under the label of SA 4Wf-j). Up to 1985, landings increased substantially but CPUE's remained in the low range (Table 8). In 1993 catches had decreased to less than 200 t (Fig. 2) and CPUE's were under 0.2 kg/crhm. A catch limit of 150 t was proposed for 1994. Over the last 2 years exploitation was curtailed by the TAC and areas fished covered 1,700 km^2 in 1994 and 1,100 km^2 in 1995. Catch-rates improved 14% from 1994 to 1995. The distribution of CPUE's (Fig. 3) shows a more fragmented exploitation of scallop beds in 1994 compared to 1995. The area with a catch-rate $\geq$ 0.8 kg/crhm (darkest shade in the contour plots) expanded from 2.4 to 8.1 km^2 during that period.

Overall, the mean weight of scallop meats shucked has been considerably smaller than in neighbouring Middle Grounds (Table 4). The average meat weight has been relatively constant over the last 5 years. The mean for 1991-1995, 15.3 g, corresponds to age 8 - 9 scallops at a count of 33 meats per 500 g. The average count in the catch came down 10% from 1994 to 1995, from 33 (16.46 g mean weight) to 30 (15.08 g mean weight) meats per 500 g.

Half of the sampling stations of the 1994 survey (Table 5) were selected to explore areas not presently fished (Fig. 4) to get baseline data. When the survey was repeated in 1995, results show no marked improvements in the densities of prerecruits but an important increase in the numbers of ages 5 and 6 (Tables 9 and 10). The recruited (age 5+) biomass estimate on a tow basis has doubled from 1994 to 1995 due to young recruits. More age 10+ scallops were also found during the 1995 survey.

German Bank

NAFO sub-subarea 4Xq includes German Bank and the lower half of the Lurcher Shoals (up to latitude 44° N); the upper half of Lurcher Shoals is part of sub-subarea 4Xr. Statistical landings and logged catches diverge for these respective areas illustrating the misrepresentation resulting from the statistical area boundaries as presently set. Biological differences exist between German Bank and Lurcher Shoals; growth rate being slower on German Bank relative to Lurcher Shoals and the outer reaches of the Bay of Fundy (Robert et al. MS 1986). Prior to the Inshore/Offshore Agreement of 1986, the offshore fleet could fish throughout the area (NAFO sub-subarea 4Xq); after 1986 their fishing activities are restricted to below latitude 43° 40' N. Table 11 provides the recent history of the German Bank fishery. Post 1975 catches for German Bank south of the Line have been estimated from logged catches for the fleet sector(s) that fished that year.

During the early 1980's, catches were important but steadily declined until 1985 (Table 11). Catch-rates were also following the same trends. After 7 years of very little activity the fishery resumed in 1993. The 1993 TAC of 200 t was caught in its entirety over a brief 6-week period starting in June; CPUE's were high at 0.756 kg / crhm. Incursions of vessels from the Bay of Fundy fleet also took place during 1993. Reports from the fishermen involved would have them fishing well into the fall. From estimates of mean landing per trip, number of vessels involved and frequency of such trips, an additional 700 t could easily have been harvested from German Bank. In 1994, the fishery proceeded on June 1st for 20 weeks until October 15th with a 200 t 'roll-over' TAC. A 'roll-over' TAC means that a 200 t quota was put in place for the period June 1st to mid-July and in-season catch-rates and counts (40 meats per 500 g) were monitored. As long as CPUE's did not drop appreciably (>25%) and meat counts were met without difficulties, an additional 200 t quota could be caught over the next 6-week period. Industry decided on the termination of the fishery after 600 t had been caught in mid-October, well in advance of the opening of the lobster fishing season in late November. Overall, the 1994 CPUE improved 10% over 1993 (Table 11). From the first period to the third and last period the weekly mean CPUE went down 20%.

In 1995 the 200 t TAC was rolled over only once and all 400 t had been caught by mid-September. The criteria for an additional TAC increment could not be met. In 1994, areas fished covered 652 km^2 but in 1995, coverage expanded 38% to 897 km^2. The overall CPUE dropped by 50% from 1994 to 1995 (Table 11). Scallop beds providing high catch-rates > 1kg/crhm were 359 km^2 in 1994; areas with such catch-rates dropped by more than 50% to 164 km^2 in 1995 (Fig. 5). The majority of areas with high catch-rates were in depths less than 100-m. At the beginning of the fishery in June, weekly catch-rates were near 0.6 kg/crhm; after a month they dropped to 0.3-0.4 and did not recover (Fig. 6). The last week's increase is questionable with only 4 observations. Prior to that CPUE's were around a low of 0.25 kg/crhm.

Sampling of the catch has been scanty or did not take place (Table 12). Since the fishery resumed in 1993, the average meat weight (16 g) in the catch corresponds to a count under 30 per 500 g. The count for German Bank is 40 meats per 500 g (average weight: 12.5 g). The meat weight distribution in 2-g interval from the catch has been plotted as percentage frequency on a Ten Minute Square (TMS) basis in figure 5. TMS are labelled with the first 3 digits of latitude and longitude at the bottom right hand corner of the TMS (see figure 5). An important mode at 12-14 g is found in all but 432661 TMS. The most heavily fished TMS, 432662, had a good mixture of meats

in the 12-16 g range but also some larger meats over 25 g (20 count). Fished areas belonging to TMS shallower than 100-m (431661, 432661, 431662, and 432662) contributed important quantities of 20 count meats. Deeper areas represented by TMS 431663, 432663, and 433663 had a meat weight profile with very few large scallops.

Figure 7 presents the distribution of locations fished on a monthly basis during the 1995 season. After the first month into the fishery (June), effort shifted appreciably in waters over 100 m where the weight distribution in the catch showed a mode of meats in the 12-14 g range (see fig. 5). Limited observations were made in September; by then, only a few vessels were active, catching up their allocations. The following table summarises the steady decline of fishery performance as the season progressed. Catch-rates dropped more than 50% while the meat count increased 30% over 3 months.

Month	Catch (class1) tons	Days fished class 1	CPUE kg/crhm	Count per 500 g
June	169.51	138	0.609	27
July	109.78	139	0.355	30
August	71.65	106	0.344	35
September	20.70	39	0.263	30

Survey work resumed in 1994. Results from the last survey in 1985 are given in table 13 for comparison. The 1985 research survey covered the German/Lurcher area while recent surveys takes place south of the 43° 40' line only. At present, commercial size scallops (age 5+) but more so large scallops (age 10+) are very abundant relative to survey results prior to 1986 (Table 14). The abundance of age 10+ scallops increased according to the 1995 survey. Given the age distribution of the scallops surveyed, they may represent a biomass accumulated over the recent past. Since the gear is unlined, the lack of young prerecruits (age 3 or less) or low density index in the survey does not indicate their absence in the stock. One tow in the high stratum, 1995 survey, had high numbers of age 2's; fishermen also reported the presence of juvenile scallops in that area later during the fishing season. Abundance of young recruits, ages 3-6, appears low. Survey results showed good densities of ages 7+.

Histograms of shell height frequencies from the 1994 and 1995 surveys (Fig. 8) show the paucity of scallops under 95 mm except for the presence of the very young prerecruits (20-40 mm shell height). In the fall of 1995, some exploratory tows within the 12-(nautical) mile limit, contiguous with this survey area, had a very similar shell height distribution (Kenchington and Lundy MS 1996). The 1995 shell height distribution pattern does not follow what one would expect from the distribution obtained in 1994. Areas surveyed vary slightly from year to year. A discrepancy still exists when comparing the 1994 height frequencies with the 1995 values but only for the area common to both surveys (bottom graph, fig. 8). A low number of survey stations, located on rocky bottoms which are difficult to sample, and the aggregated nature of scallops contributed to the observed differences. Only 13 stations from the 1995 survey were located in the area surveyed in 1994. Variability of scallop abundance between stations was extreme. In the area common to both surveys, age 7 scallops range from 0 to 176 in 1995 and from 0 to 25 in the outside area.

DISCUSSION AND CONCLUSION

Starting in 1994, all scallop fishing grounds on the Scotian Shelf were managed by quota divided into entreprise allocations. The meat count is 45 meats per 500 g on the eastern Scotian Shelf and 40 on the western Scotian Shelf.

Eastern Scotian Shelf

The present management plan is focusing on a recovery strategy. Effort has declined after 1993 while catch-rates increased. Fishery performance improved 15% from 1994 to 1995. Higher densities of older scallops were also observed in the 1995 research survey.

Higher exploitation of Middle Grounds should be discouraged. Commercial catch-rates improved only slightly from 1994 to 1995. The research survey recruit index also improved because of the influx of new recruits (ages 5-6). But signs of prerecruits are very weak.

The fleet experienced better catch-rates on Sable / Western in 1995. The 1995 abundance index from research surveys rose due to increased densities of young recruits (ages 5-6) and to greater numbers of older (age 10+) scallops. The influx of new recruits contributed 40% to doubling the recruited biomass. However, exploitation of the new recruits would contribute little yield to the fishery at 60 - 90+ meats per 500 g. The presence of the large scallops (age 10+) could justify a modest increase (15-25 t) in the TAC to 165-175 t. Fishable areas identified by areas that have been exploited at one point during the 15 years existence of this fishery, cover 3,700 km^2 but the fleet tends to congregate; about 1,100 km^2 were fished in 1995. So local areas may experienced higher effort (Fig. 3). TAC increases should be approached cautiously to allow biomass levels to raise in order to sustain moderate exploitation over the long term.

German Bank

TAC increments of 200 t rolled over only once in 1995. Criteria of stable catch-rates and meat counts for additional quota to be fished could not be met farther along in the fishing season. The incremental TAC had the advantage of allowing exploitation even though information about the scallop stock was somewhat limited and prevented overharvesting.

There was a drop of 50% in commercial catch-rates from 1994 to 1995 even though the fleet expanded effort over 33% more grounds. Fishable biomass was no better on grounds not previously exploited than on the beds fished in 1993-94. CPUE's declined early within the 1995 fishing season (Fig. 6) and remained at that level until the fishery stopped. The meat count increases 30% over the course of a 4-month fishery. Survey results showed good densities of old (age 10+) scallops and some younger age groups. However, the survey took place before the fishery started so densities (especially older scallops) may have been reduced significantly. The fishery performance at the end of the season with much lower catch-rates and higher counts would indicate that directing for aggregations of large scallops was becoming difficult. Evidence of recruitment (age 2) over some of the beds are good.

Catch levels of 200 - 300 t have not been sustainable in the early 1980's. The rapid decline in the 1995 fishery performance would suggest that recent catch levels are not sustainable and that a TAC of 100 t would be more appropriate. Catch-rates and meat counts should be monitored before considering further increase(s).

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Table 1.- Biological data on growth-rate (von Bertalanffy parameters) and meat yield (year round values of meat weight over shell height) for scallop fishing grounds on the Scotian Shelf. N = number of scallops examined.

	Growth	Yield
Banquereau Bank	N = 60	N = 90
	H_{∞} = 128.105 mm	intercept = -11.003
	t_0 = 1.5233	slope = 2.913
	k = 0.2579	
Middle Grounds	N = 414	N = 289
	H_{∞} = 156.210 mm	intercept = -10.305
	t_0 = 1.3650	slope = 2.801
	k = 0.1980	
Sable, Western Bank	N = 3,716	N = 3,734
	H_{∞} = 136.628 mm	intercept = -11.381
	t_0 = 1.3375	slope = 2.999
	k = 0.2269	
German Bank	N = 600	N = 598
	H_{∞} = 130.945 mm	intercept = -13.750
	t_0 = 1.3870	slope = 3.463
	k = 0.2300	

Table 2.- Fishery characteristics for the Banquereau Bank area (NAFO 4V) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Catches are from logbook information. Effort is calculated from Class I data. h: hours; crhm: crew-hour-meter.

Year	Landings	Catches	Effort		CPUE	
			h 10^3	crhm 10^3	kg/h	kg/crhm
1980	3.30	7.17	0.16	20	45.90	0.355
1981	0.00	0.00	-	-	-	-
1982	0.69	0.42	0.01	1	45.45	0.387
1983	5.37	3.26	0.06	7	56.18	0.444
1984	3.18	0.63	0.01	1	68.18	0.672
1985	0.24	0.00	-	-	-	-
1986	15.64	11.15	0.35	47	31.81	0.239
1987	0.65	0.51	0.01	4	15.15	0.110
1988	0.00	0.00	-	-	-	-
1989	0.00	0.00	-	-	-	-
1990	0.83	0.00	-	-	-	-
1991	0.63	0.81	0.01	3	28.64	0.240
1992	2.82	2.50	0.01	8	34.21	0.303
1993	5.79	6.84	0.19	26	36.96	0.264
1994	0.00	0.00	-	-	-	-
1995	0.00	0.00	-	-	-	-

Table 3.- Fishery characteristics for Middle Grounds (NAFO 4We) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Catches are from logbook information. Effort is calculated from Class I data. h: hours; crhm: crew-hour-meter.

Year	Landings	Catches	Effort		CPUE	
			h 10^3	crhm 10^3	kg/h	kg/crhm
1980	3.65	1.42	0.04	5	33.20	0.262
1981	0.00	0.00	-	-	-	-
1982	72.39	62.09	0.89	124	69.50	0.501
1983	105.16	104.92	2.54	323	41.24	0.325
1984	11.90	9.94	0.44	59	22.83	0.175
1985	26.89	21.59	0.77	99	27.86	0.217
1986	51.27	51.28	2.86	351	17.91	0.146
1987	6.70	7.03	0.37	47	19.18	0.150
1988	0.28	0.29	0.01	2	21.54	0.169
1989	20.84	21.70	0.55	67	39.70	0.326
1990	19.04	33.63	0.94	110	35.92	0.306
1991	31.54	35.18	0.83	96	42.62	0.365
1992	38.68	43.12	1.26	152	34.25	0.284
1993	39.11	53.72	1.67	201	32.09	0.267
1994	12.61	12.97	0.32	35	40.77	0.372
1995	17.79	17.79	0.36	47	50.12	0.379

Table 4.- Nature of the catch from NAFO SA 4W determined by analyses of scallop meat weights.

	% catch examined / catch landed	meat weight (g) mean	min	max	s.e.	n meats
Middle Grounds						
1983	0.0240	20.00	3.04	69.99	0.13	1,259
1984	0.0392	14.84	4.23	46.97	0.14	314
1985	0.0175	22.88	6.31	66.40	0.22	217
1986	0.0134	22.73	4.33	61.51	0.23	302
1987	0.0436	21.48	2.34	68.23	0.30	137
1988	-	-	-	-	-	-
1989	0.0441	14.46	4.22	61.45	0.11	636
1990	0.0417	16.45	5.74	59.69	0.16	483
1991	-	-	-	-	-	-
1992	-	-	-	-	-	-
1993	0.0125	13.45	5.38	68.45	0.13	499
1994	-	-	-	-	-	-
1995	0.0564	14.20	6.44	56.88	0.08	707
Sable Island/Western Bank						
1980	0.0133	9.46	3.87	22.11	0.04	860
1981	-	-	-	-	-	-
1982	0.0015	9.15	4.65	15.38	0.11	102
1983	0.0339	13.49	2.25	72.43	0.04	4,658
1984	0.0161	11.10	2.65	42.48	0.07	1,034
1985	0.0025	27.41	11.27	54.30	0.52	62
1986	0.0271	15.03	2.33	79.13	0.03	11,397
1987	0.0319	14.35	2.22	98.14	0.04	9,226
1988	0.0045	11.57	4.07	34.60	0.09	394
1989	0.0215	13.14	3.16	72.91	0.02	8,440
1990	0.0099	13.97	2.52	71.89	0.05	2,994
1991	0.0050	13.08	4.25	31.31	0.04	1,365
1992	0.0114	15.37	3.46	59.51	0.04	3,526
1993	0.0178	16.58	2.55	68.88	0.07	2,022
1994	0.0168	16.46	3.99	52.97	0.08	1,055
1995	0.0495	15.08	3.63	44.48	0.03	4,341

Table 5.- Number of survey stations in NAFO SA 4V and 4W by year and by stratum type.

Banquereau Bank	1987	1988	1989	1990	1991	1992
exploratory	5	5	6	0	0	0
total	5	5	6	0	0	0

Middle Grounds	1989	1990	1991	1992	1993	1994	1995
explo/low catch	0	0	0	8	0	12	12
medium catch	-	-	-	-	-	-	-
high catch	-	-	-	-	-	-	-
total	0	0	0	8	0	12	12

Sable/Western Bank	1989	1990	1991*	1992	1993	1994	1995
low catch	11	10	4	20	21	15	15
medium catch	33	30	22	24	29	13	13
high catch	62	50	50	26	18	1	1
exploratory	-	-	-	12	12	29	29
total	106	90	76	82	80	58	58

* The original allocation by stratum was not followed in 1991. Shipcrew overtime restrictions did not allow for the scheduled coverage of the sampling area.

Table 6.- Average number of scallops at age caught in a lined 2.44m New Bedford offshore dredge by catch stratum, Middle Grounds. A new survey series starts in 1994.

	Age (years)									Mean	s.d.
	2	3	4	5	6	7	8	9	10+		
1984 stock survey											
low	0	0	0	2	1	2	1	0	0	8	10
high	0	0	0	2	6	4	2	1	2	17	16
1985 stock survey											
low	0	0	3	6	2	4	1	0	0	20	23
high	0	0	0	0	0	3	3	0	1	10	13
1986 stock survey											
low	0	0	0	0	0	0	1	1	3	7	7
high	0	0	1	0	3	6	4	2	2	17	10
1987 stock survey											
low	0	2	0	1	1	0	0	1	2	6	8
high	0	0	0	0	0	1	1	0	3	6	4
Stratified average for each survey:											
1983	0	0	2	21	7	0	0	0	1		
1984	0	0	0	2	4	3	1	1	1		
1985	0	0	2	3	1	4	2	0	1		
1986	0	0	1	0	2	4	3	2	2		
1987	0	1	0	1	1	1	1	1	3		
1988 stock survey											
exploratory	5	10	16	4	2	1	1	1	2	51	56
1992 stock survey											
exploratory	1	6	3	7	3	1	1	0	0	22	27
1994 stock survey											
exploratory	0	0	0	3	3	1	1	0	4	12	12
1995 stock survey											
exploratory	0	0	3	15	18	3	2	1	6	48	119

Table 7.- Summary of average number of scallops at age caught for prerecruits, shell height under 75mm or age less than 5 years, and recruits, shell height over 75mm by catch stratum, for Middle Grounds.

	Age (years)		
	2-4	5-10	11+
Middle Grounds			
1983 stock survey			
low	0	1	0
medium	2	23	1
high	3	40	1
1984 stock survey			
low	0	6	0
high	0	16	1
1985 stock survey			
low	3	13	0
high	0	6	1
1986 stock survey			
low	0	4	1
high	1	16	1
1987 stock survey			
low	2	4	1
high	0	3	2
1988 stock survey			
exploratory	31	10	1
1992 stock survey			
exploratory	10	12	0
1994 stock survey			
exploratory	0	8	4
1995 stock survey			
exploratory	3	40	5

Table 8.- Fishery characteristics for the Sable Island, Western Bank area (NAFO 4Wf-j) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Catches are from logbook information. Effort is calculated from Class I data. h: hours; crhm: crew-hour-meter.

Year	Landings	Catches	Effort		CPUE	
			h 10^3	crhm 10^3	kg/h	kg/crhm
1980	60.99	50.48	1.66	220	30.50	0.229
1981	0.56	0.00	-	-	-	-
1982	64.10	61.40	1.80	244	34.13	0.252
1983	185.15	166.47	7.14	895	23.31	0.186
1984	71.30	64.65	3.04	376	21.30	0.172
1985	64.93	76.00	2.54	295	29.92	0.258
1986	618.35	585.26	26.72	3251	21.90	0.180
1987	415.80	412.01	20.20	2452	20.40	0.168
1988	100.43	100.42	3.58	442	28.02	0.227
1989	516.39	515.36	15.67	1930	32.88	0.267
1990	414.25	403.94	14.64	1683	27.59	0.240
1991	356.40	352.57	10.85	1241	32.49	0.284
1992	482.57	477.88	17.68	1975	27.03	0.242
1993	204.46	186.11	8.39	969	22.17	0.192
1994	103.53	97.02	3.18	365	30.49	0.266
1995	132.23	132.23	3.39	438	38.97	0.302

Table 9.- Average number of scallops at age caught in a lined 2.44 m New Bedford offshore dredge by catch stratum in the Sable Island - Western Bank area. A new survey series (*) starts in 1994.

	Age (years)									Mean	s.d.
	2	3	4	5	6	7	8	9	10+		
1992 stock survey											
low	13	3	8	8	6	4	2	1	3	49	77
medium	4	8	22	12	12	7	3	2	3	74	69
high	14	8	20	17	15	8	3	1	1	88	95
1993 stock survey											
low	1	7	6	7	6	4	3	2	4	39	37
medium	2	14	15	24	10	6	3	2	4	79	77
high	4	22	25	35	20	11	4	1	1	123	62
1994 stock survey											
exploratory	2	3	7	8	6	4	2	1	5	38	11
low	9	25	30	11	5	4	3	2	4	92	70
medium	2	5	7	7	6	5	2	1	4	40	10
high	0	0	0	10	6	1	1	1	5	24	-
1995 stock survey											
exploratory	5	4	7	11	15	8	5	3	10	68	16
low	10	13	44	26	14	6	4	2	8	127	86
medium	2	4	5	10	13	9	4	2	6	55	15
high	1	0	0	1	4	4	1	1	2	12	-
Stratified average for each survey:											
1984	10	4	4	8	6	3	2	1	4		
1985	30	41	23	14	10	6	5	2	6		
1986	1	2	3	2	1	1	1	1	5		
1987	8	16	24	25	12	4	2	2	5		
1988	21	34	40	42	25	9	3	2	3		
1989	5	21	31	27	16	7	3	1	3		
1990	13	6	17	20	16	7	2	1	2		
1991	2	14	6	9	10	7	3	1	2		
1992	10	7	17	13	11	7	3	1	2		
1993	2	12	13	19	10	6	3	2	3		
1994*	4	9	13	9	6	4	2	1	4		
1995	5	6	16	15	14	7	4	2	8		

Table 10.- Summary of average number of scallops at age per tow for prerecruits (shell height under 75 mm or age less than 5 years) and recruits (shell height over 75 mm) by catch stratum in the Sable Island - Western Bank area. Explo: exploratory.

	Age (years)		
	2-4	5-10	11+
1988 stock survey			
low	4	2	2
medium	17	28	3
high	114	95	2
1989 stock survey			
low	16	12	3
medium	6	19	3
high	92	82	1
1990 stock survey			
low	6	9	2
medium	11	24	2
high	56	67	1
1991 stock survey			
low	17	41	3
medium	15	27	2
high	25	32	1
1992 stock survey			
explo/very low	4	10	4
low	24	22	2
medium	34	37	2
high	42	43	1
1993 stock survey			
explo/very low	8	16	3
low	14	23	3
medium	31	46	3
high	51	72	0
1994 stock survey			
explo/very low	12	22	4
low	64	26	3
medium	14	22	3
high	0	20	4
1995 stock survey			
explo/very low	15	43	8
low	65	54	6
medium	13	40	4
high	1	12	1

Table 11.- Landings for German Bank (NAFO 4Xq) for all fleet sectors until 1986 inclusive. After 1986 landings are for the deep-sea fleet only. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Catches for German Bank only, south of lat. 43 °40' N have been estimated from logbook information for all fleet sectors. Effort is calculated from Class I data from the deep-sea fleet. h: hours; crhm: crew-hour-meter.

Year	Landings	Catches	Effort		CPUE	
			h 10^3	crhm 10^3	kg/h	kg/crhm
1968	15.77					
1969	33.26					
1970	10.01					
1971	16.91					
1972	4.68					
1973	1.63					
1974	0.00					
1975	0.00					
1976	18.84					
1977	0.32					
1978	0.00					
1979	102.32	350.49	2.89	375	121.22	0.934
1980	1269.71	638.12	7.26	909	84.03	0.671
1981	379.69	185.74	1.45	198	109.46	0.880
1982	659.74	243.71	4.52	544	52.48	0.436
1983	587.76	225.52	4.61	537	48.90	0.420
1984	207.13	63.09	1.86	200	33.92	0.316
1985	33.76	11.25	0.39	45	28.89	0.250
1986	1.59	1.00	0.00	0	-	-
1987	0.00	0.00	-	-	-	-
1988	0.00	0.00	-	-	-	-
1989	5.54	5.00	0.07	10	63.68	0.440
1990	0.00	0.00	-	-	-	-
1991	0.00	0.00	-	-	-	-
1992	0.25	0.25	<0.01	<1	126.50	0.998
1993	200.00*	200.00*	1.63	255	118.46	0.756
1994	599.67	599.67	4.64	720	129.16	0.833
1995	399.43	399.42	6.33	933	63.10	0.428

*minimum removals.

Table 12.- Nature of the catch from German Bank determined by analyses of scallop meat weights from the offshore fleet for selected years when a fishery took place.

	% catch examined	meat weight (g)				n meats
	catch landed	mean	min	max	s.e.	
1983	0.0010	11.99	3.35	44.13	0.11	533
1984	0.0008	22.69	3.88	53.52	0.42	81
1989	0.1012	47.93	27.41	76.19	0.32	117
1993	0.0142	17.41	5.20	67.10	0.06	1,635
1994	0.0129	16.59	6.03	67.04	0.03	4,678
1995	0.0469	16.05	3.99	71.95	0.02	11,672

Table 13.- Average number of scallops at age caught in an unlined 2.44 m New Bedford offshore dredge by catch stratum on German Bank. Pre-1994 data for comparison only.

	Age (years)									Mean	s.d.
	2	3	4	5	6	7	8	9	10+		
1985 stock survey											
low	0	0	0	0	0	1	2	2	8	13	7
medium	0	0	0	0	2	6	4	3	7	28	30
high	0	0	0	3	5	6	5	3	5	27	37
1994 stock survey											
exploratory	0	0	0	2	12	31	30	18	13	107	107
low	0	0	1	3	2	4	4	5	7	25	41
medium	0	0	0	4	3	1	1	2	10	21	41
high	2	1	8	20	64	17	3	5	51	172	315
very high	0	0	0	0	0	1	4	10	89	103	82
1995 stock survey											
low	0	0	0	0	1	2	5	5	4	17	9
medium	0	0	0	0	0	5	4	2	2	13	13
high	82	13	16	3	11	36	29	16	65	271	129
very high	0	1	1	1	6	17	22	18	48	112	32
Stratified average for each survey:											
1985	0	0	0	1	3	6	4	3	6		
1994	0	0	1	4	14	15	13	11	33		
1995	18	4	4	1	6	19	21	15	45		

Table 14.- Summary of average number of scallops at age per tow for prerecruits (shell height under 75 mm or age less than 5 years) and recruits (shell height over 75 mm) by catch stratum. Pre-1994 data for comparison only.

	Age (years)		
	2-4	5-10	11+
German Bank / Lurcher 1985			
low	0	6	7
medium	0	17	5
high	0	24	3
German Bank 1994			
exploratory	0	101	5
low	1	22	3
medium	0	13	8
high	11	117	43
very high	0	29	75
German Bank 1995			
low	0	15	2
medium	0	12	1
high	110	104	56
very high	2	77	35

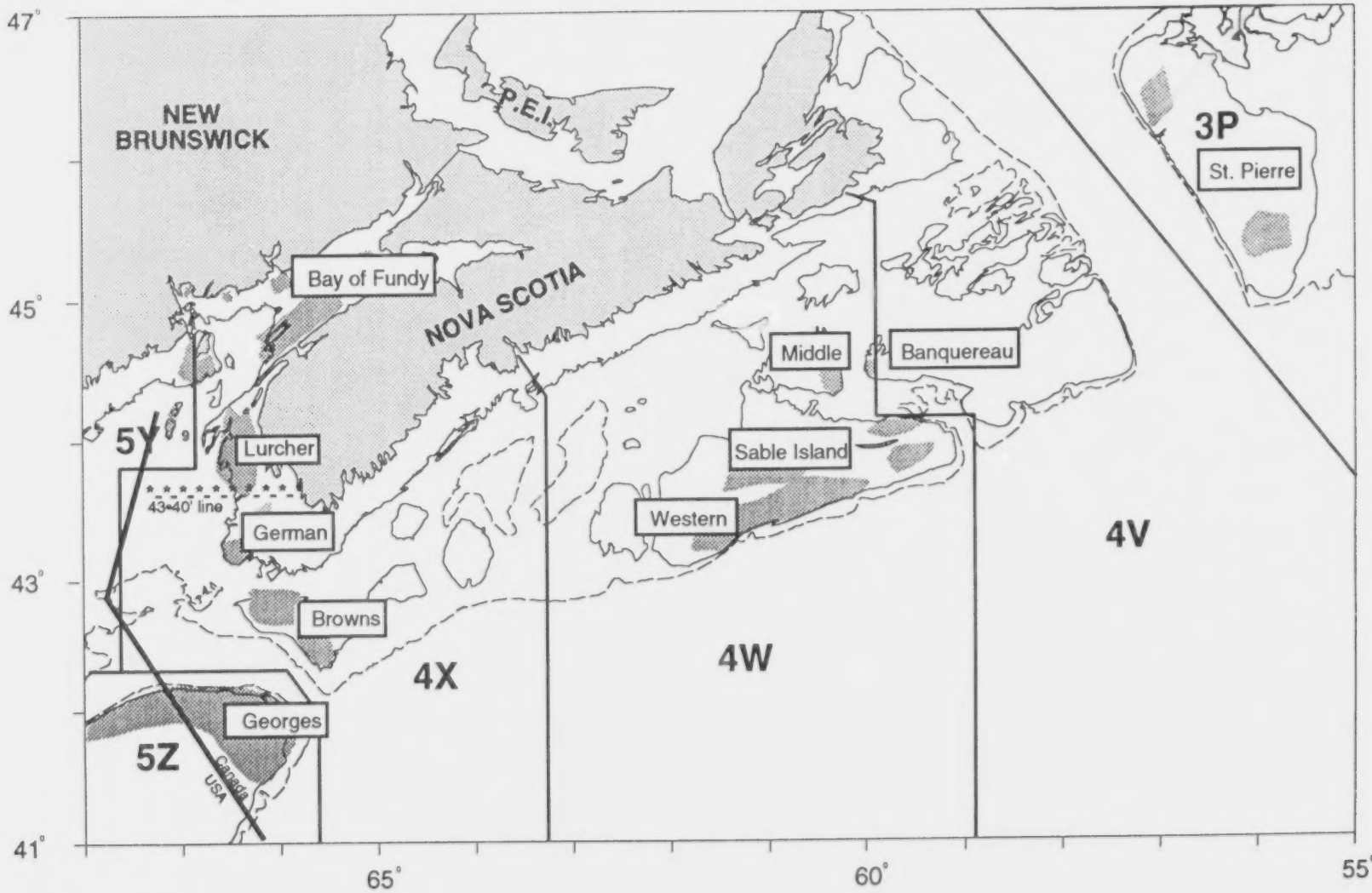

Figure 1.- Scallop fishing areas on the Scotian Shelf. The 100 and 200-m isobaths are represented.

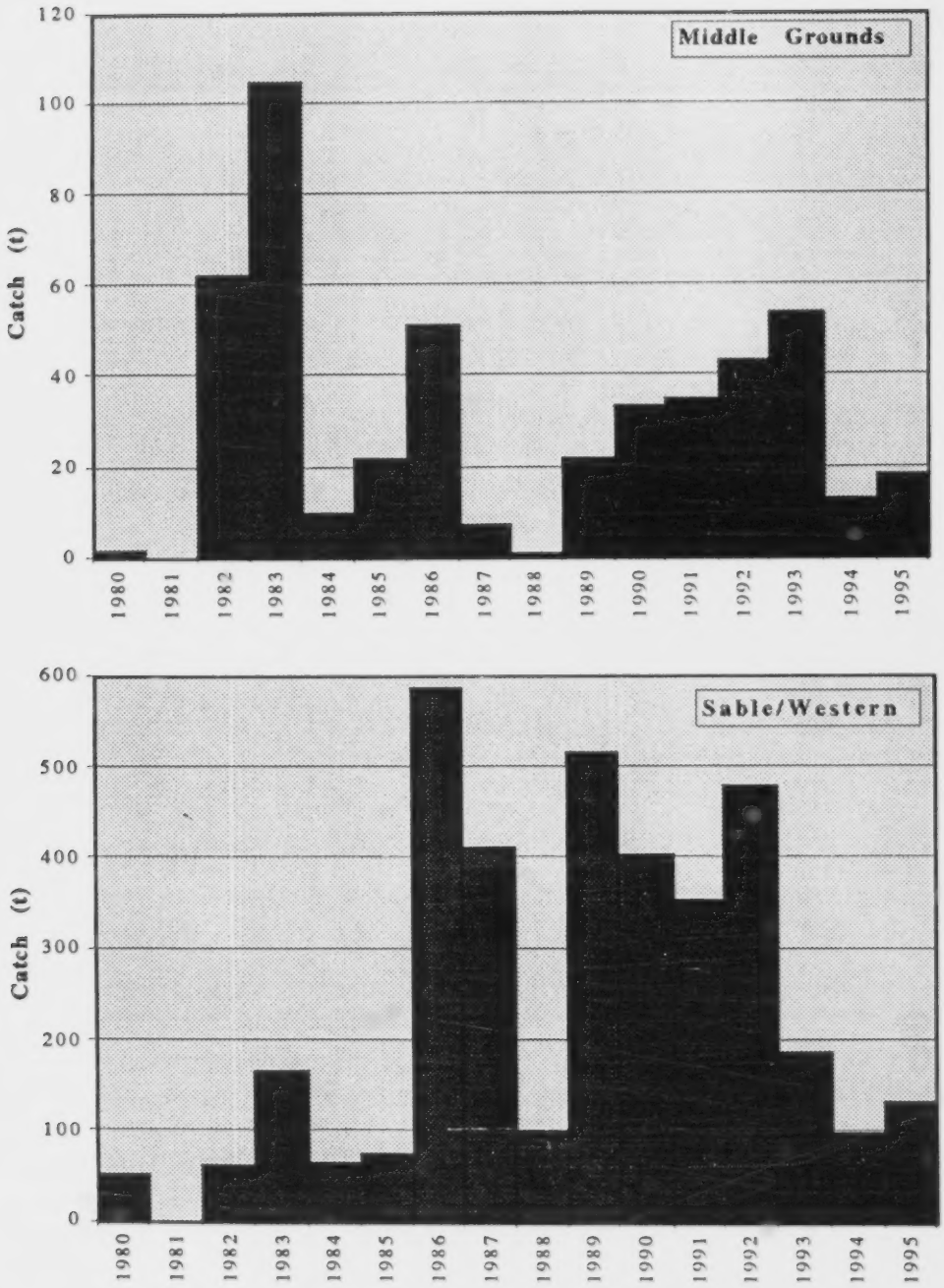

Figure 2.- Catches in tons of scallop meats for the eastern Scotian Shelf.

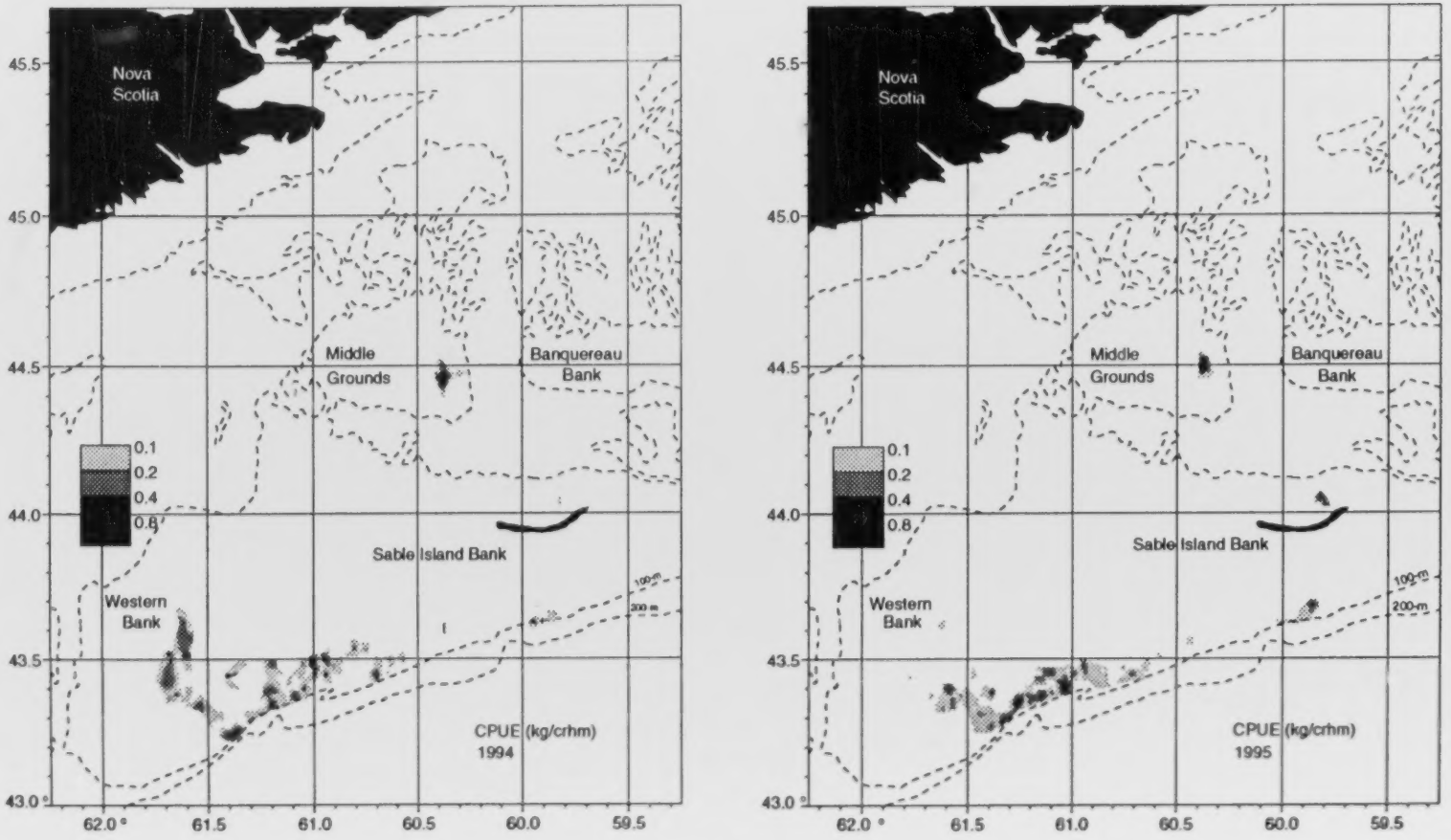

Figure 3.- Distribution of commercial CPUE on the eastern Scotian Shelf in 1994 (left) and 1995 (right).

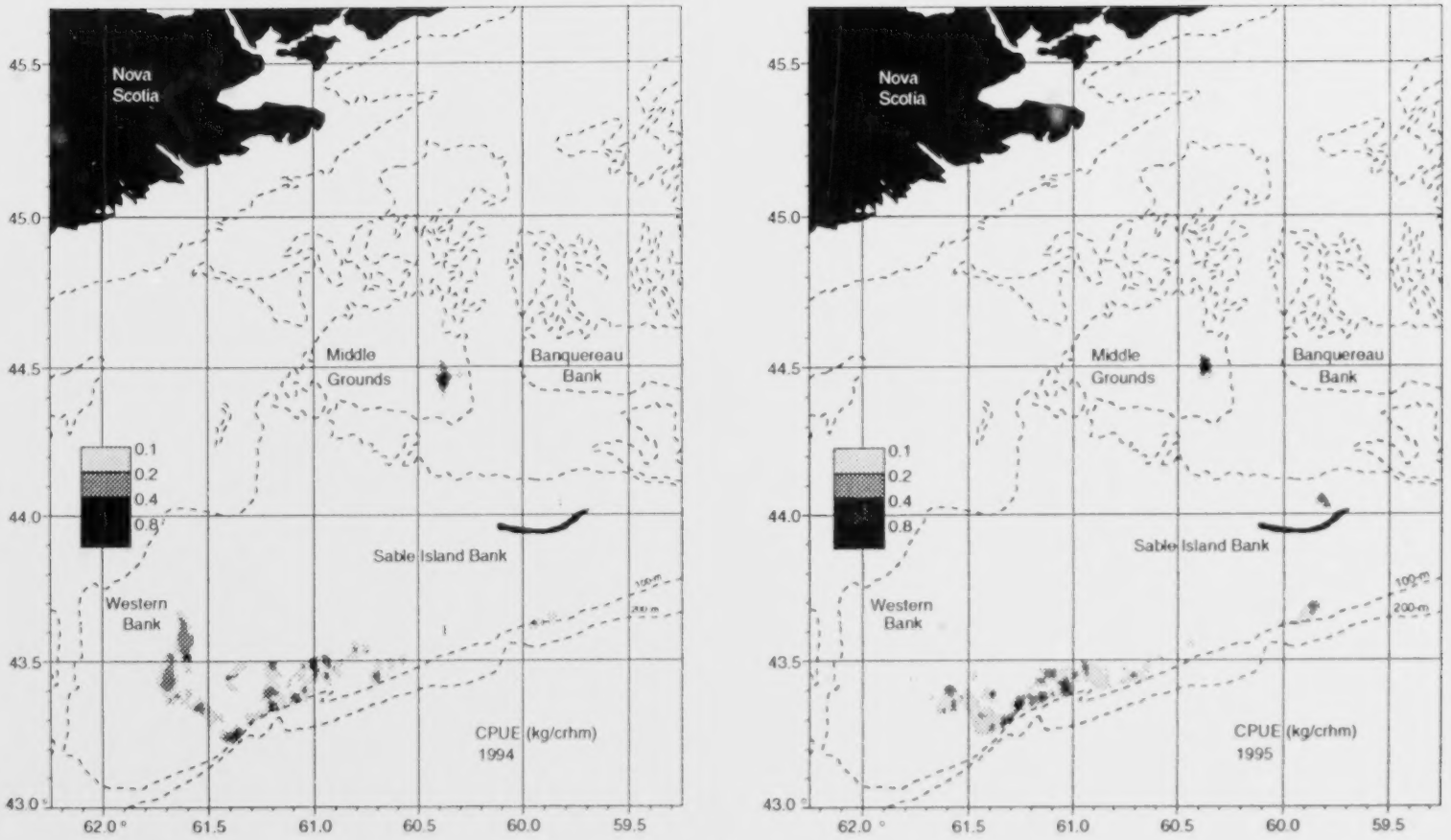

Figure 3.- Distribution of commercial CPUE on the eastern Scotian Shelf in 1994 (left) and 1995 (right).

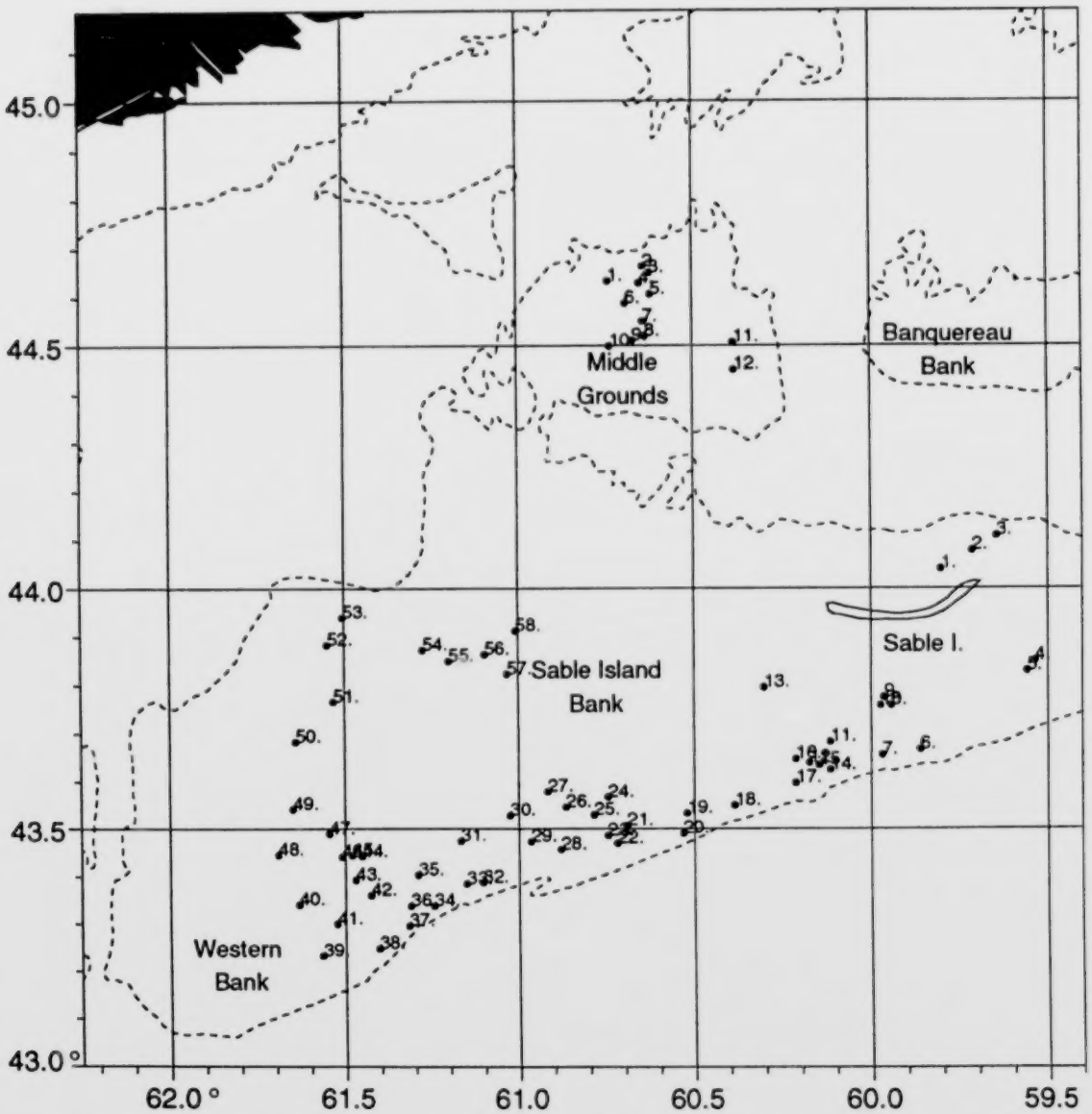

Figure 4.- Location of survey stations of the 1995 eastern Scotian Shelf stock survey. The dashed line is the 100-m isobath.

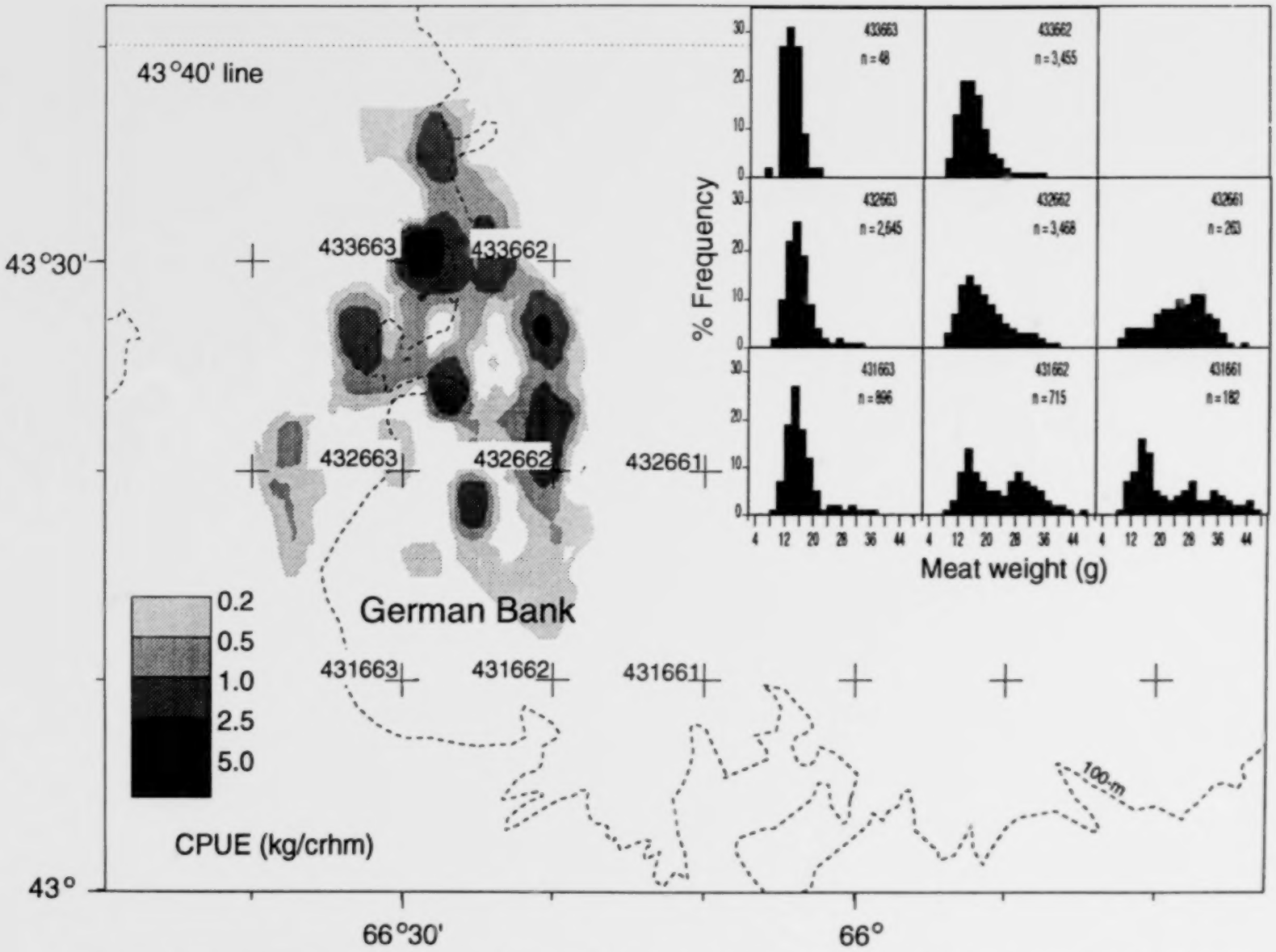

Figure 5.- Distribution of commercial catch-rates and frequency of meat weight in the catch according to Ten Minute Squares labeled with the first 3 digits of the latitude and longitude at the right hand bottom corner of the square. The 100-m isobath is represented.

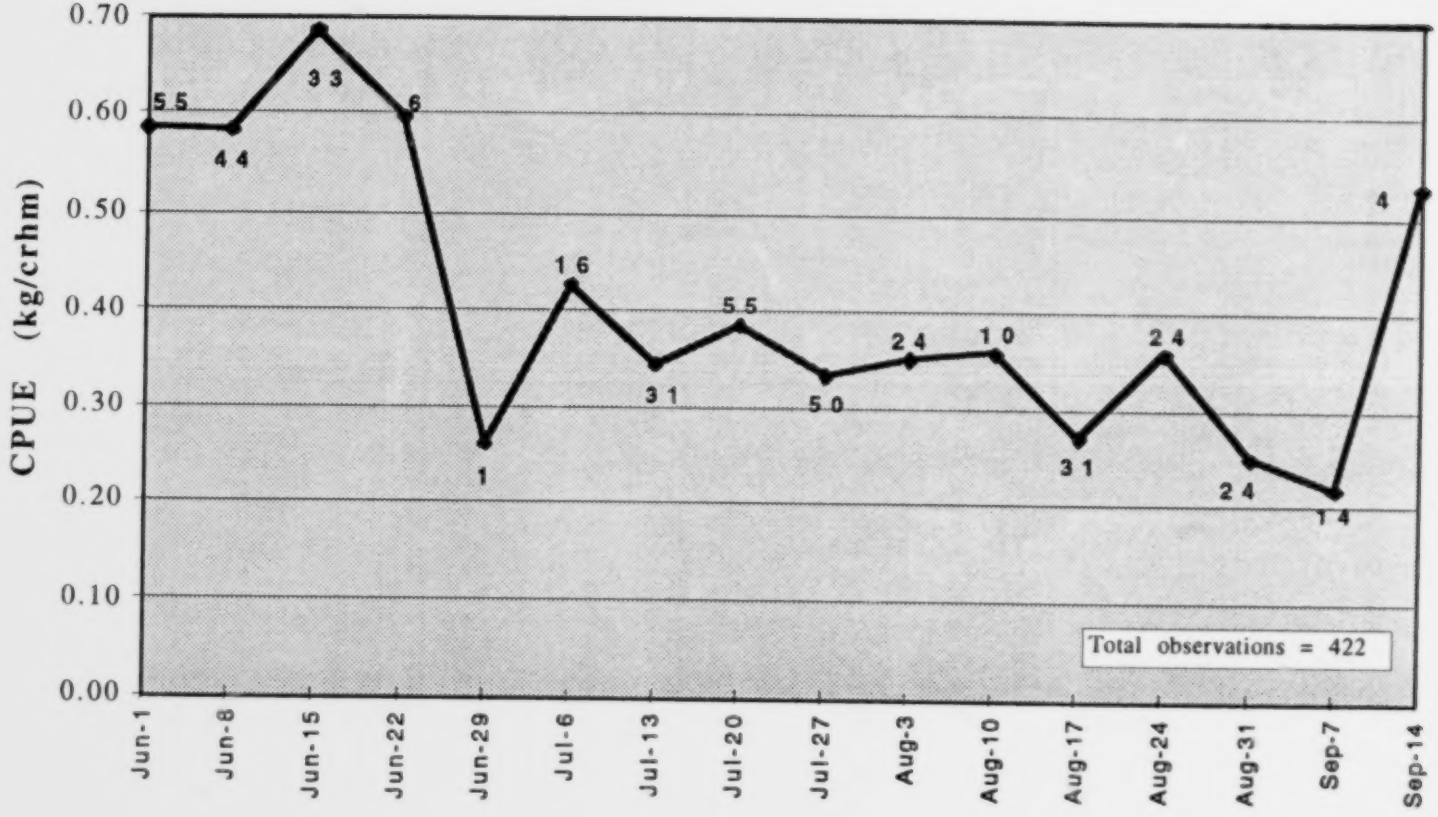

Figure 6.- Fluctuations in weekly catch-rates during the 2 periods of the 1995 German Bank fishery. The total number of days fished during the week is indicated on the graph. The second period started July 15th.

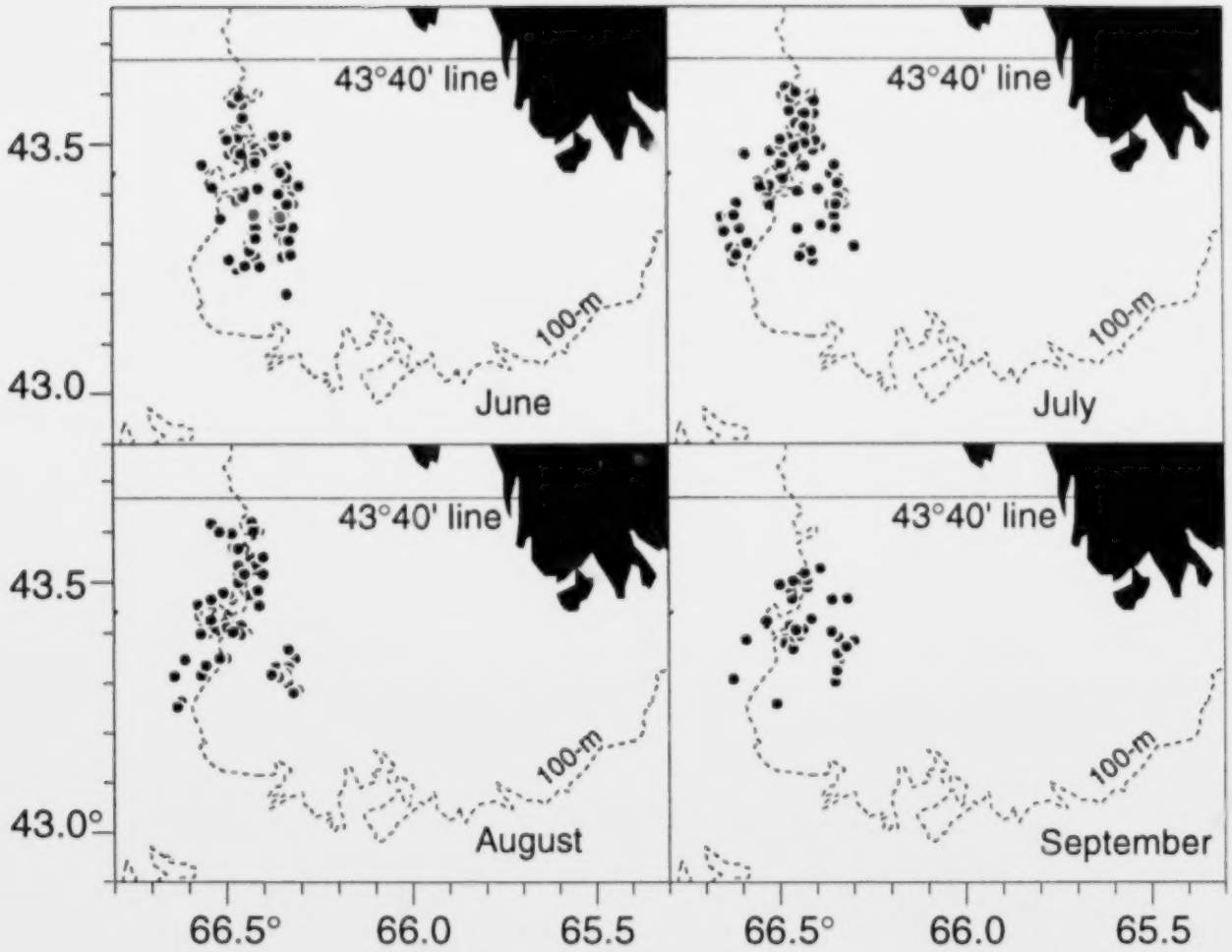

Figure 7.- Distribution of effort according to daily fishing positions during the 1995 German Bank fishing season.

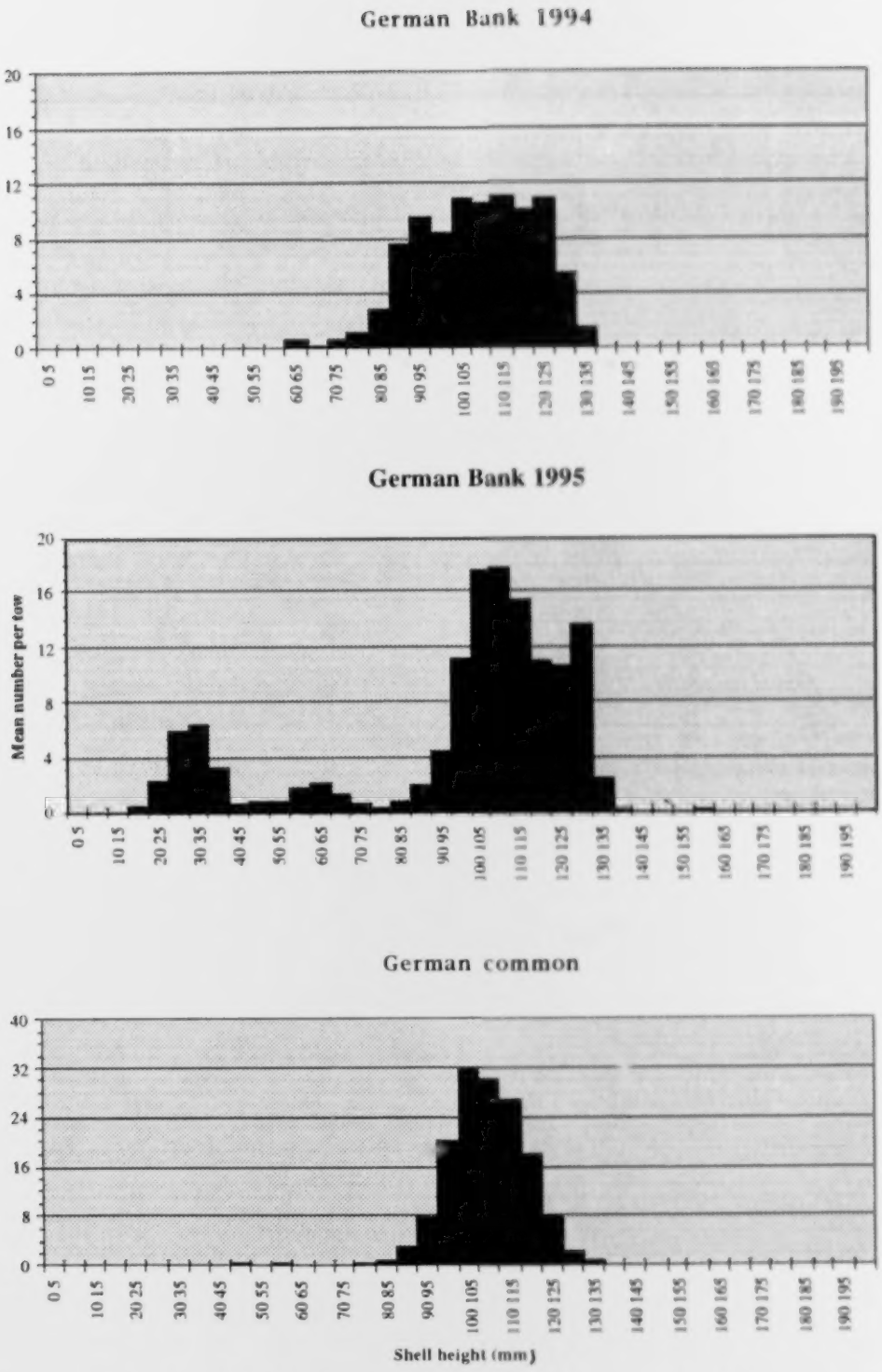

Figure 8.- Profile of shell height distribution, German Bank recent surveys.